

HUMPHREYS & ASSOCIATES

EVMS & Scheduling Leader

Establishing a Performance Measurement Baseline (PMB) in a Cost Effective Manner

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What is EVM?

- EVM is a **project management** process emphasizing:
 - Disciplined up-front project planning
 - Work measurement
 - Problem analysis
 - Future performance forecasting
 - Technical, cost, schedule and risk integration/ management
- EVM is an “Industry Best Practice” for project management (ANSI/EIA 748 – Earned Value Management Systems)

Why use EVM?

EVM enhances the chances of program/project success:

- You Can't **Succeed**, If You Can't **Manage**
- You Can't **Manage**, What You Can't **Measure**
- You Can't **Measure**, What You Can't **Define**
- You Can't **Define**, What You Can't **Understand**



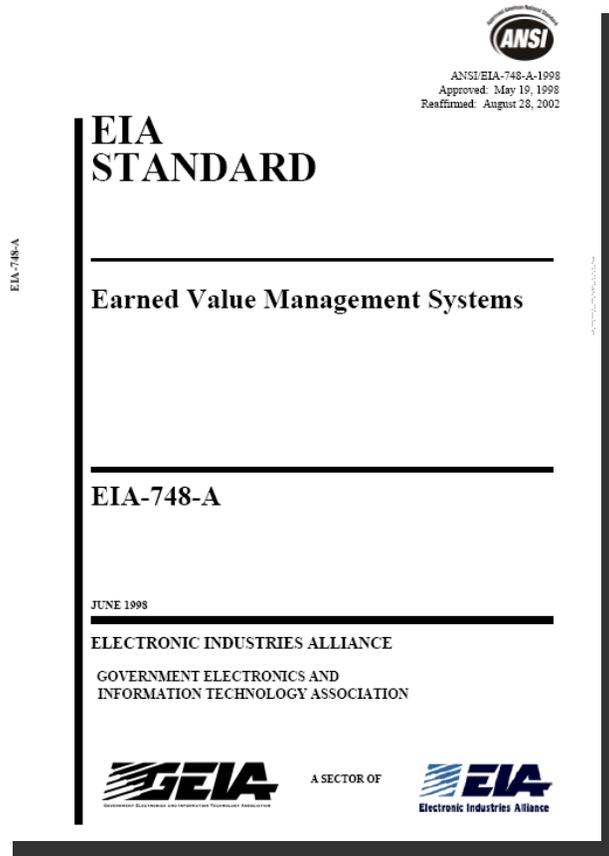
EVM Policies (Over-arching)

- [ANSI/EIA STD 748 Earned Value Management Systems \(EVMS\)](#)
 - [Provides EVMS guidelines](#) for organizations to implement an effective EVM System
- [OMB Circular A-11, Part 7, Capital Programming Guide \(CPG\)](#)
 - Sets forth the Earned Value Management (EVM) requirements for Government Agencies
- [Federal Acquisition Regulations \(FAR\)](#)
 - Requires EVM on all development contracts and subcontracts for major acquisitions, irrespective of contract type

EVM Policies (NASA)

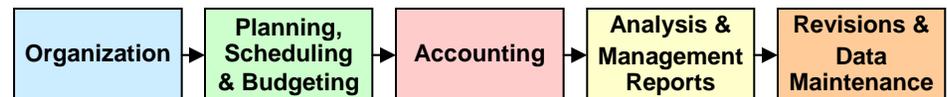
- NPR 7120.5D NASA Space Flight Program and Project Management Requirements
 - Requires ANSI EIA-748 compliant EVM on all contracts exceeding \$50M in initial or modified contract value
 - Requires EVM Principles on all flight systems and ground support projects (contractor and civil service) exceeding \$20M total project cost
 - Requires Integrated Baseline Reviews (IBRs) within six months after contract award or approval of the Project Plan; and within two months after definitization of significant scope changes or budget realignment
- NPR 7120.5C NASA Program and Project Management Processes and Requirements
 - Same thresholds as 7120.5D
 - Applies to Non-Space Flight Programs and Projects
- NASA FAR SUPPLEMENT - PART 1834
 - NFS Subpart 1834.2 Earned Value Management System
 - Provisions 1852.234-1 and Clause 1852.234-2

EVM Guidelines



Five Guideline Areas: (32 Guidelines)

- **Organization (5)**
 - Define contractual effort and assign responsibilities for the work
- **Planning, Scheduling & Budgeting (10)**
 - Plan, schedule, budget and authorize the work
- **Accounting Considerations (6)**
 - Accumulate costs of work and material
 - Report on progress/accomplishments to date
- **Analysis & Management Reports (6)**
 - Compare planned, earned and actual costs, analyze variances and develop estimates of final costs
- **Revisions & Data Maintenance (5)**
 - Incorporate internal and external changes



EVM Guideline Summary

CATEGORY	NUMBER OF QUESTIONS	GUIDELINE SUMMARY CONTENTS
Organization	5	Define the authorized work and assign responsibility for work. Integrate planning, scheduling, work authorization, and accounting systems.
Planning & Budget	11	Plan, schedule, budget and authorize work. Establish and maintain a time-phased budget baseline.
Accounting Consideration	6	Accumulate costs of work and material.
Analysis and Management Reports	5	Compare planned and actual cost, and analyze variances. Identify managerial actions taken. Horizontal and vertical communications and traceability. Develop revised estimates of cost at completion.
Revisions & Data Maintenance	5	Timely incorporation of contractual changes. Maintain traceability from original budgets. Prohibit retroactive changes. Access to data.

EVM - Performance Management Overview

EVM Principles

(ANSI/EIA-748-1998)

Organize (WBS & OBS)

Plan, Schedule and Budget
(Build the Performance Measurement Baseline)

Revisions
(Change Control)

Accounting

Analysis
(Cost/Schedule Variances, Trends, EAC and Risk)

Internal Changes

Performance Management Cycle

Source: A Guide to the Project Management Body of Knowledge™,

Initiate

Plan

Execute

Control

Close out

Features of a “Good” EVM system

- Thorough up-front planning based on a detailed product-oriented WBS, incorporating Risk Management
 - Timely performance measurement baseline (PMB) establishment and control
 - Information broken down by product (WBS) as well as by organization or function
- Objective measurement of technical accomplishment against the plan at levels where the work is being performed

Features of a “Good” EVM system (Cont.)

- Reporting consistency and discipline – a structured process and methodology
- Summarized data reporting to higher management (performance metrics) for use in effective decision making (Measures Outcomes)
- Provides for analysis of significant variances and their impact on the project
- Facilitates proper management actions to mitigate risk and manage technical, cost and schedule performance

Benefits of Using EVM

- Facilitates understanding, assessing and quantifying of what a performing organization is achieving with program dollars.
- Relates resource planning, technical and schedule requirements to project risk
- Provides Project Management with **objective, accurate and timely data** for effective decision making
- Helps identify problems not previously known
- Provides better capability to trace problems to their source
- Allows more efficient use of management resources, by identifying and focusing on problem areas
 - Detail planning at levels where work is performed allows management attention to be directed to areas where significant problems are indicated.

Benefits of Using EVM (Cont.)

- Quantifies the impact of technical, cost and schedule decisions made to date
- Facilitates forecasting of future project performance based on trends to date
- Provides useful performance history for future project cost estimating

Project Specific Benefits of EVM

- Allows the Project Management and Technical Staff to have *increased understanding and confidence* that:
 - Technical content of the scope of the work has been captured
 - Accurate schedules exist with
 - Network Logic
 - Horizontal Traceability
 - Vertical Traceability
 - There are adequate assignment of resources to complete ALL the work on contract
 - Project risk is identified
 - A solid foundation for effective project execution is in place

Basic EVM Terms

- The PMB or “The Plan” - Budgeted Cost for Work Scheduled (BCWS)
 - The sum of the time-phased budgets established for all effort (including in-process work) scheduled to be accomplished within a given time period.

Earned Value – Budgeted Cost for Work Performed (BCWP)

- The sum of the time-phased budgets for work **actually completed** during a specified time period
 - BCWP is the budgeted value for the work actually accomplished
 - Earned Value can Only be Determined After the Performance (or scheduled performance) of Work
- Budget At Completion (BAC)
 - The budgetary goal (excluding MR) for accomplishment of all authorized work.

Basic EVM Terms

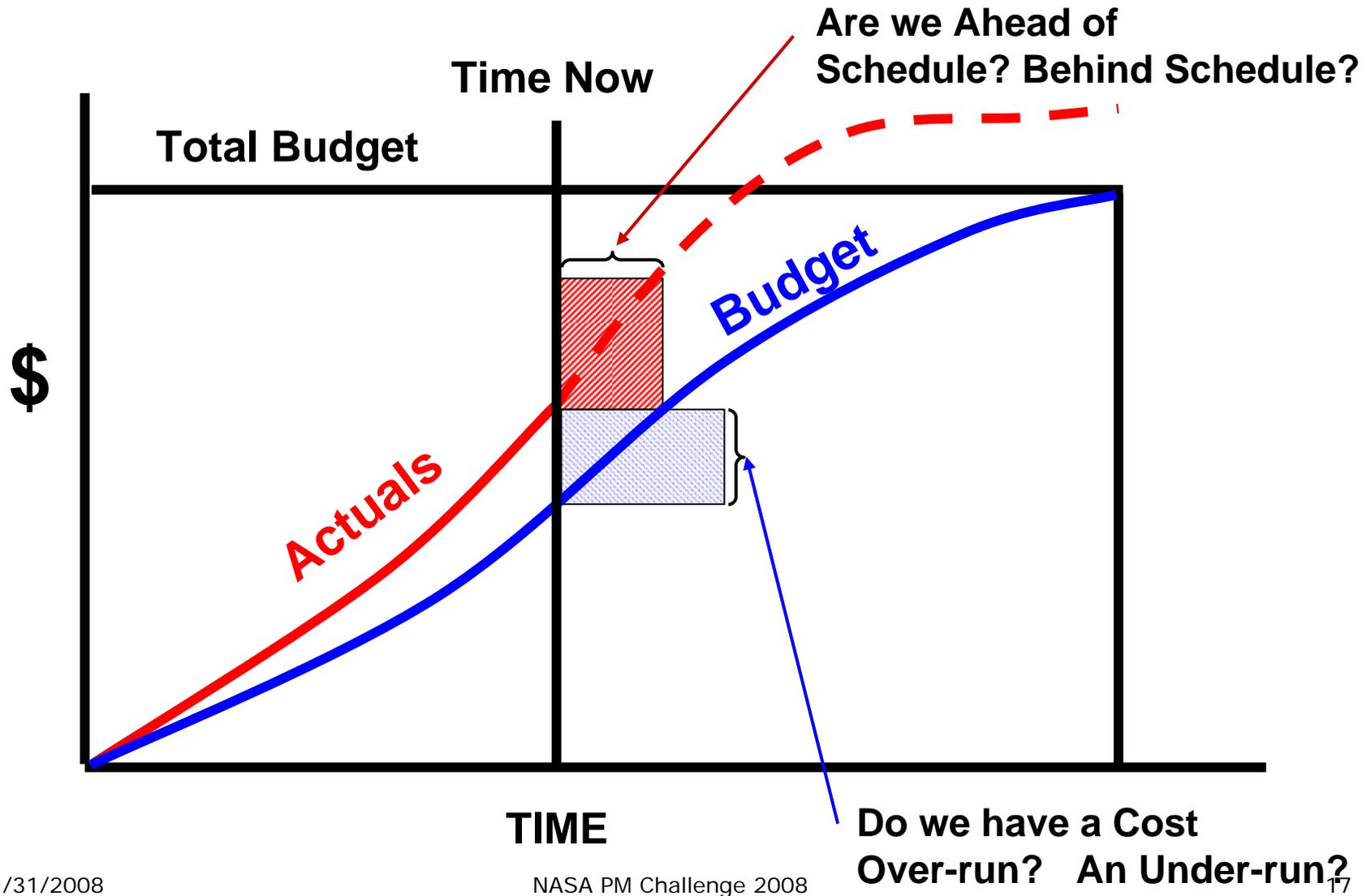
- “The Actuals” – Actual Cost of Work Performed (ACWP)
 - The costs (taken from the Accounting System) actually incurred (or in some cases estimated) and recorded, in accomplishing the work performed within a given time period.
 - Labor
 - Direct Labor
 - Civil Service Labor (when applicable)
 - Support Contractors
 - Material
 - Subcontractor/vendor
 - Other Direct costs
 - Indirect Costs



Basic EVM Terms

- Management Reserve (MR) - An amount of the total allocated budget INITIALLY withheld for management control purposes rather than designated for the accomplishment of a specific task or set of tasks.
 - There is no specific scope of work associated with management reserve budget
 - Held for UNKNOWN but in-scope future effort
 - MR is not used to cover cost overruns!
- Undistributed Budget (UB) - Budget applicable to contract effort which has not yet been identified to CWBS elements at or below the lowest level of reporting to the Government.
 - Temporary holding account until work/budget can be allocated to Control Accounts
 - Usually within two accounting periods

Questions to Answer...



Are the numbers misleading?

Planned vs. Actuals Example

	Oct	Nov	Dec	Jan	Feb	Mar	Timenow	Cumulative
Planned Spend (\$)	10	15	10	25	20	20		100
Actual Spend (\$)	9	22	12	30	22	20		115
Variance	1	-7	-2	-5	-2	0		-15%

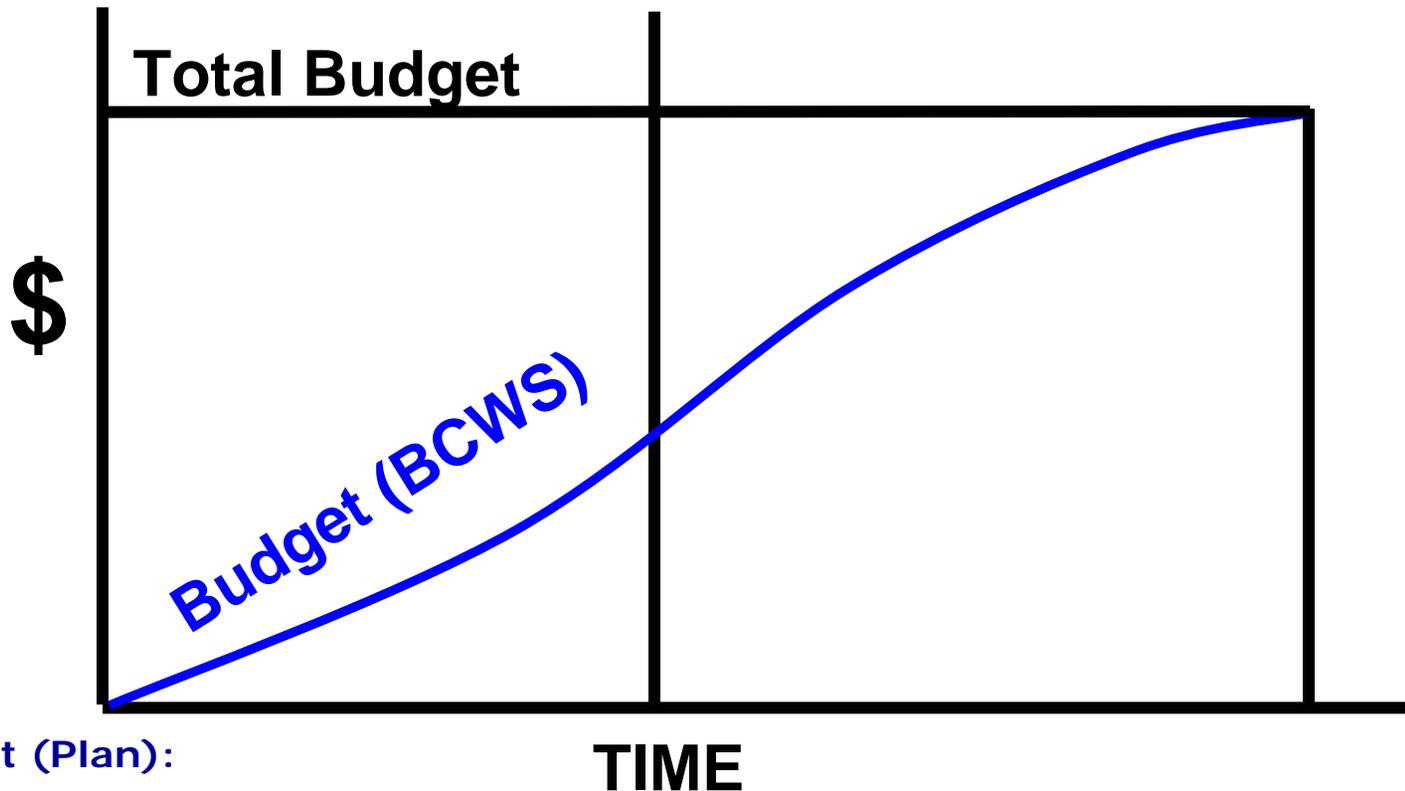
- Will Plan vs. Actuals answer these questions...
 - Can we tell, from the numbers, is the project on schedule...Ahead? Behind?
 - How is the project performing...Favorable? Unfavorable?
 - Will the project complete within budget?

Ahead of Schedule?
Over-running Cost?

When Earned Value is added, the picture will become CLEAR.

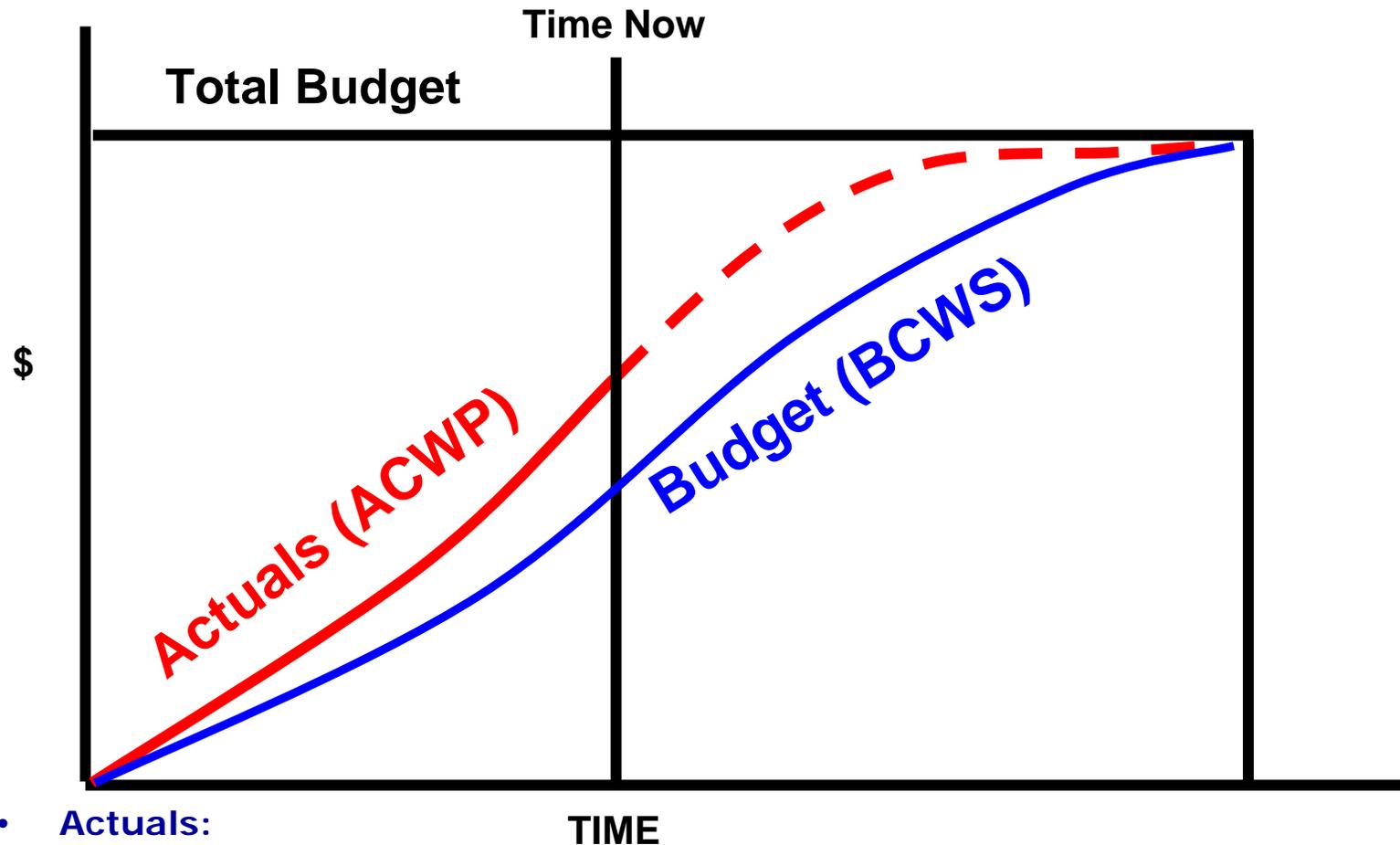
Key Elements of Earned Value – “Plan (Budget)”

Time Now



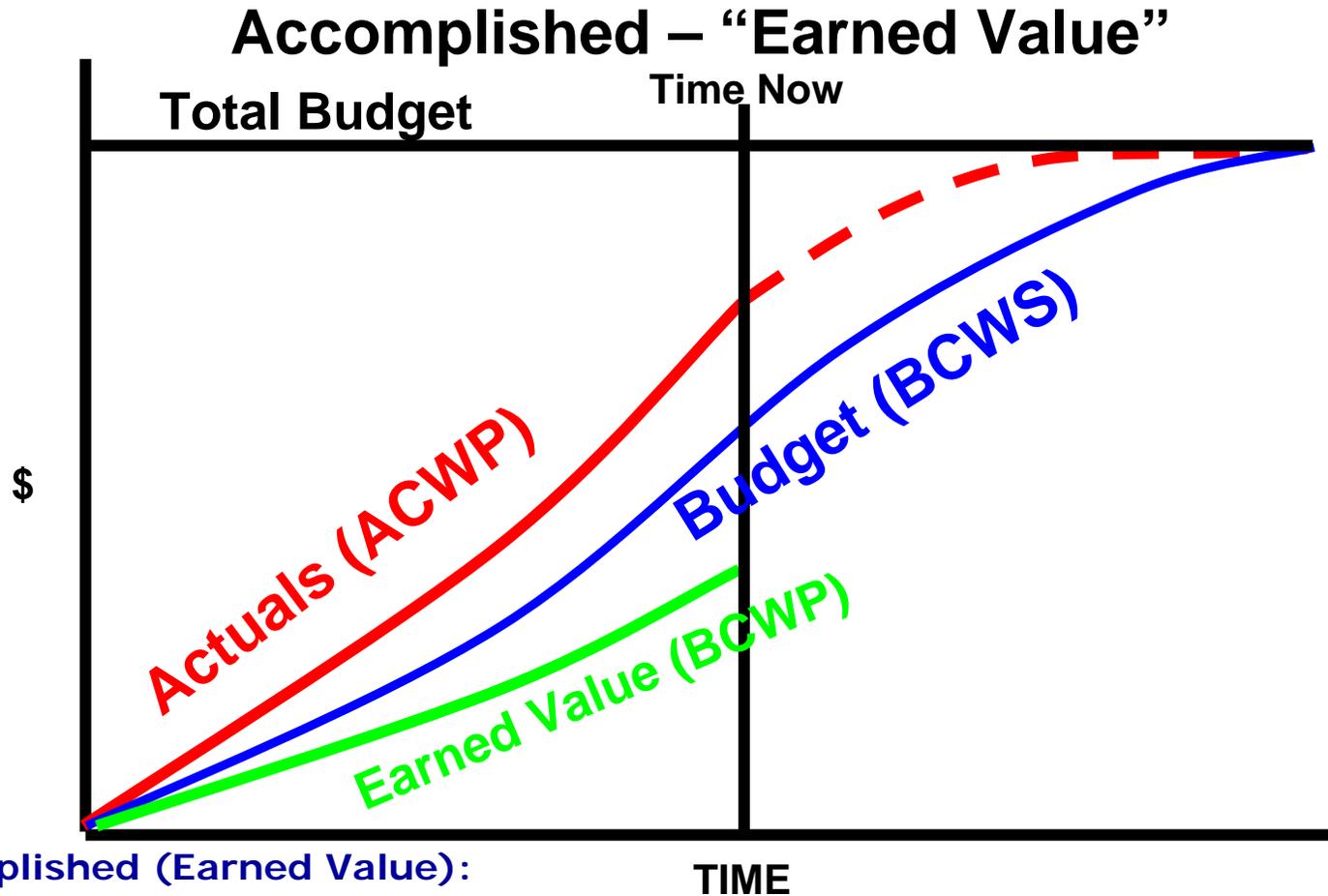
- Budget (Plan):
 - The schedule to build project equity from zero to the BAC
 - We expect gain in project earned valued as each piece of work is completed
 - “Budget Cost of Work Scheduled (BCWS)”

Elements of Earned Value – “Actuals”



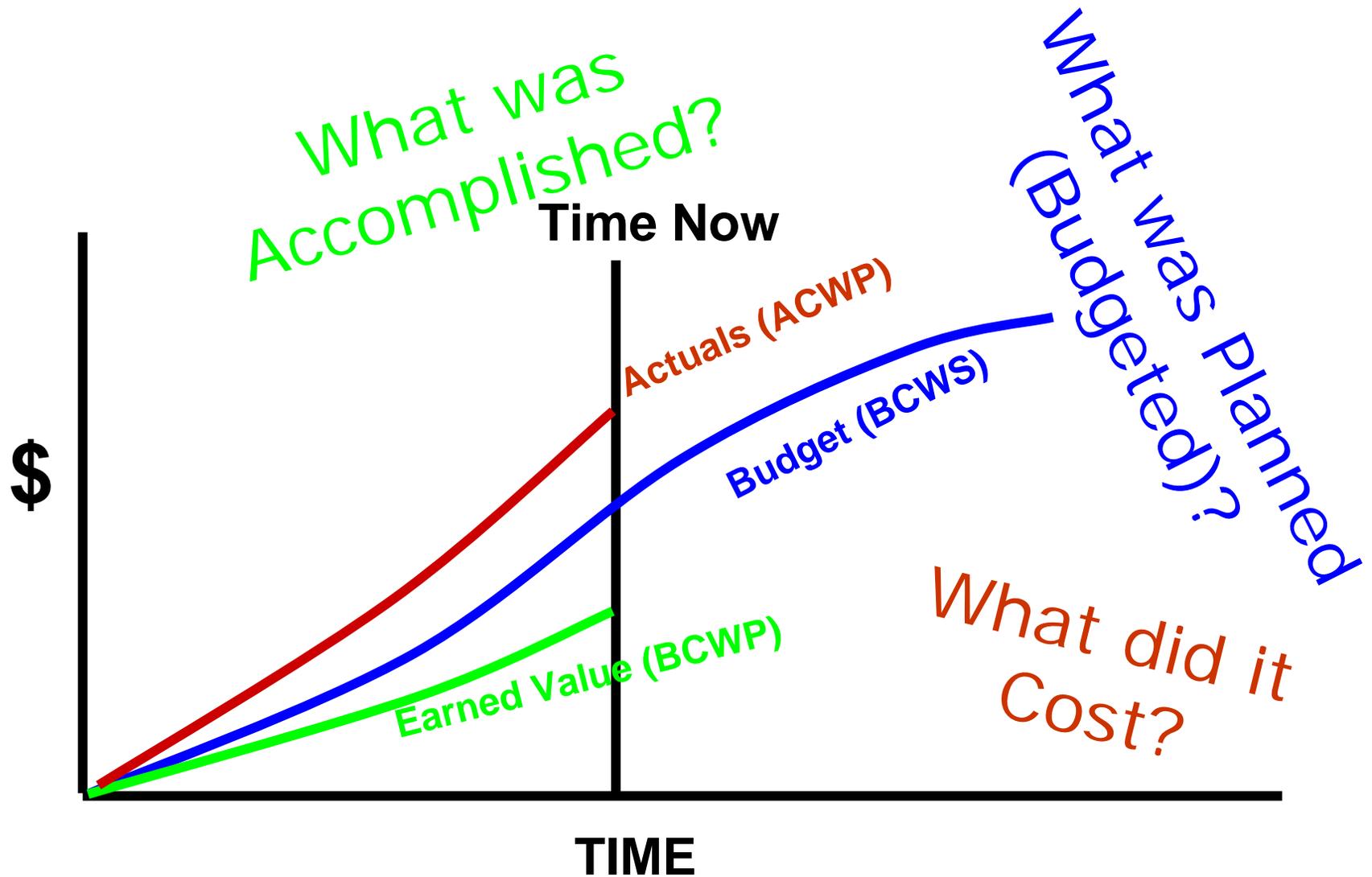
- **Actuals:**
 - The total cost of the completed work
 - “Actual Cost of Work Performed” (ACWP)

The Missing Element??



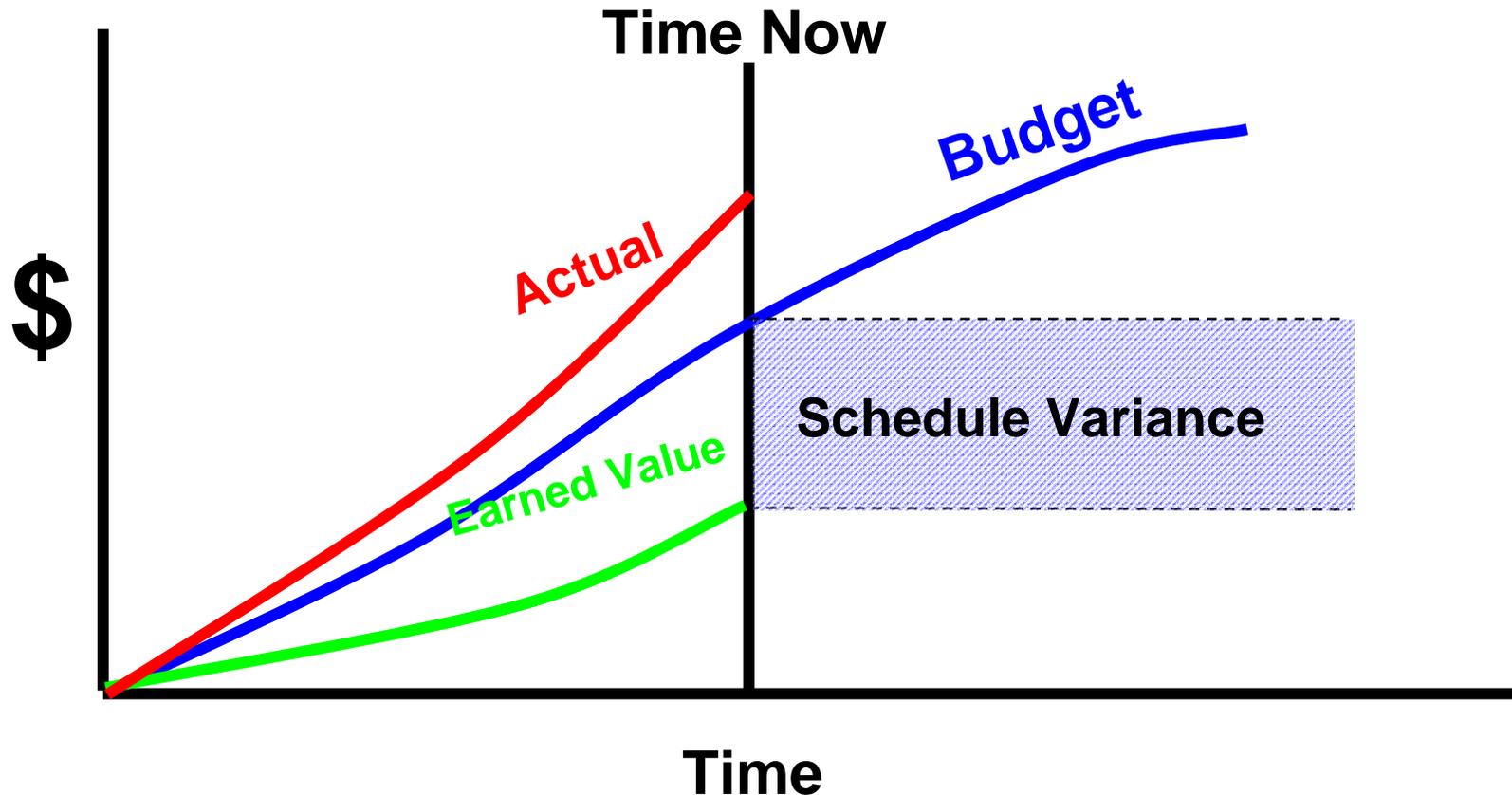
- **Accomplished (Earned Value):**
 - The project work accomplished, regardless of the cost to accomplish the work
 - The gain in project earned value as a result of completed work
 - “Budgeted Cost of Work Performed” (BCWP)

What Can We Learn?



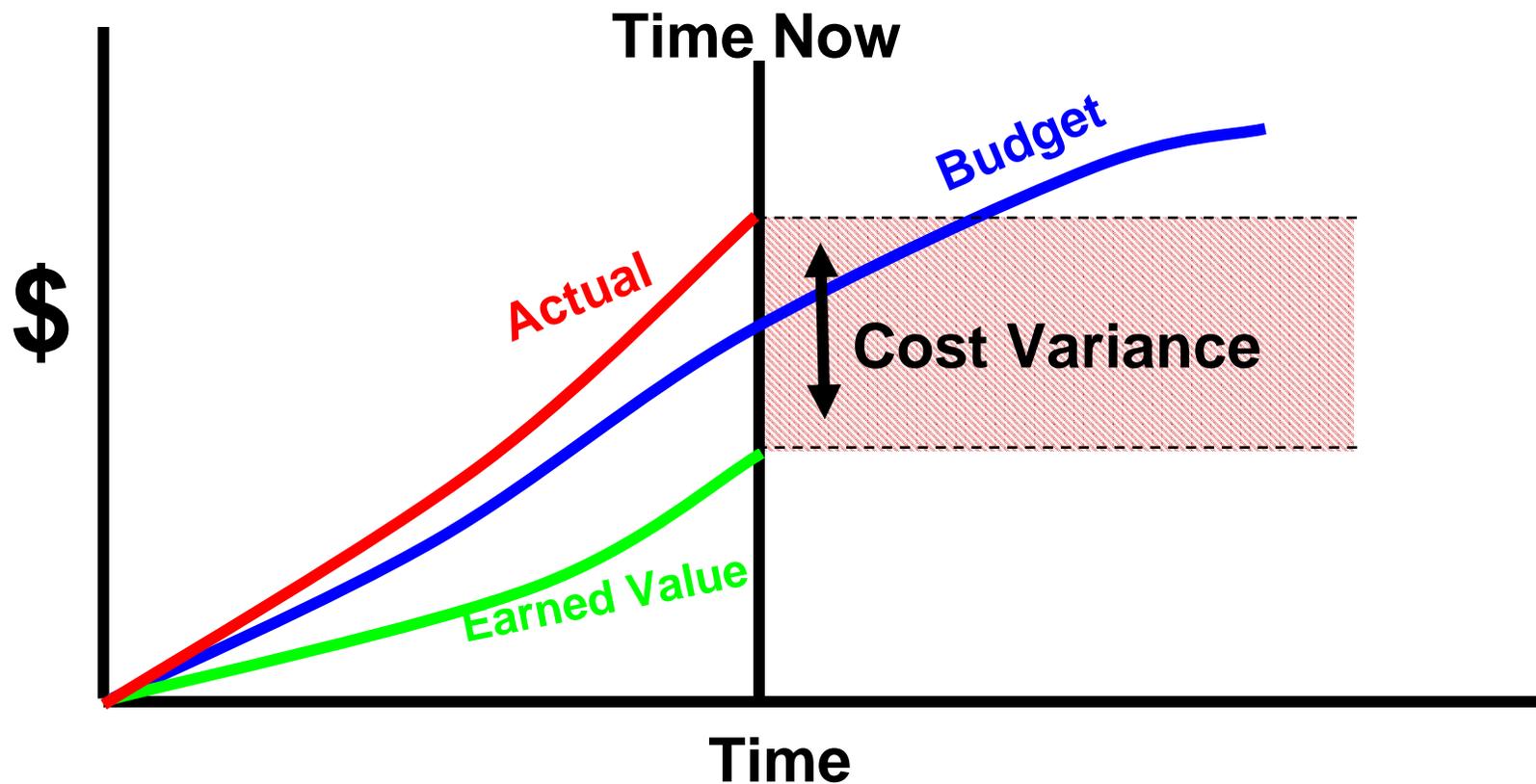
Earned Value – Schedule Variance

- Earned Value – Plan = Schedule Variance
 - This is only one indicator of whether we are Ahead of or Behind Schedule

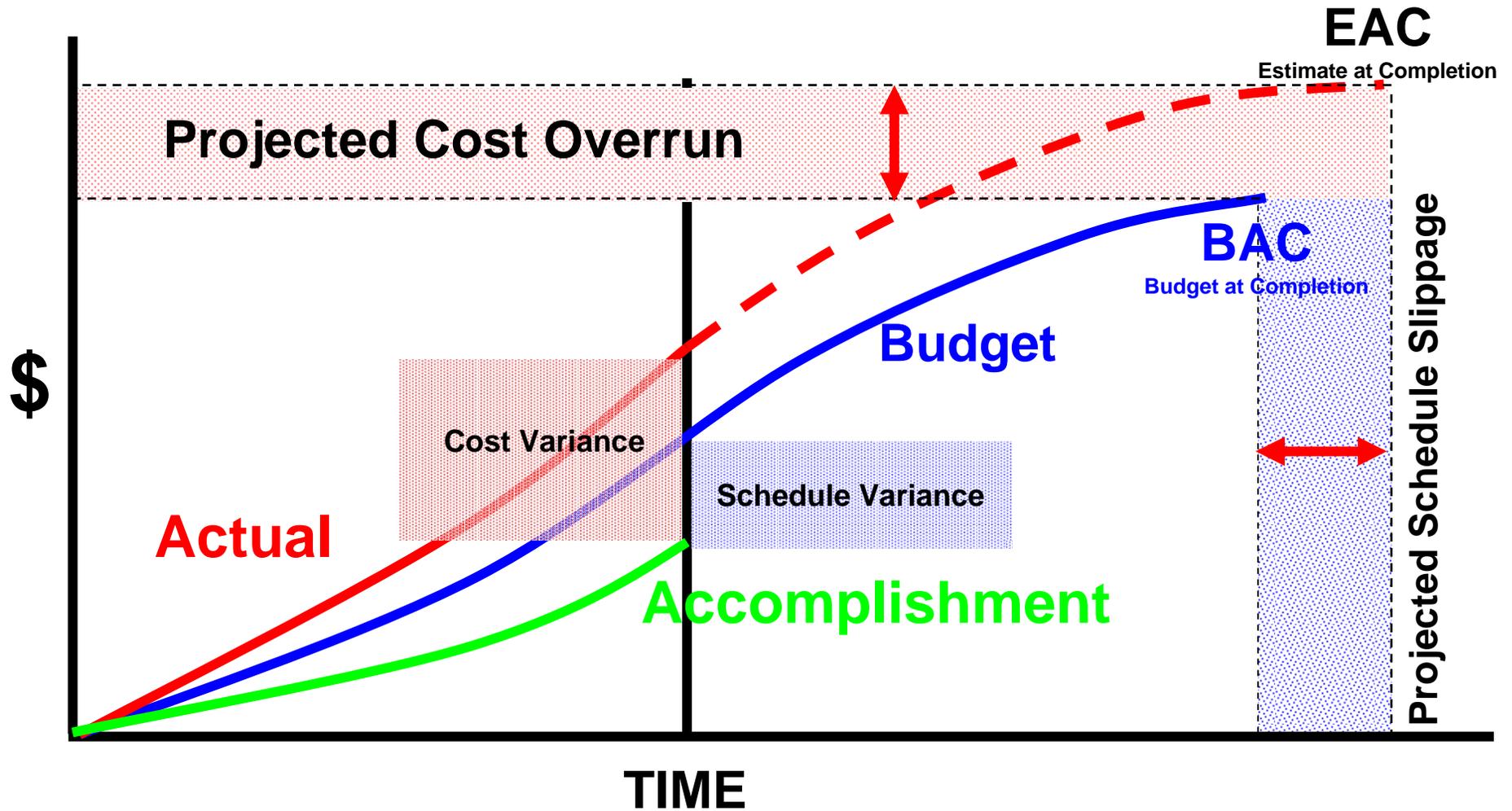


Earned Value – Cost Variance

- **Earned Value – Actuals = Cost Variance**
 - Indicator of whether the Project is over-running or under-running Cost



EVM Benefits



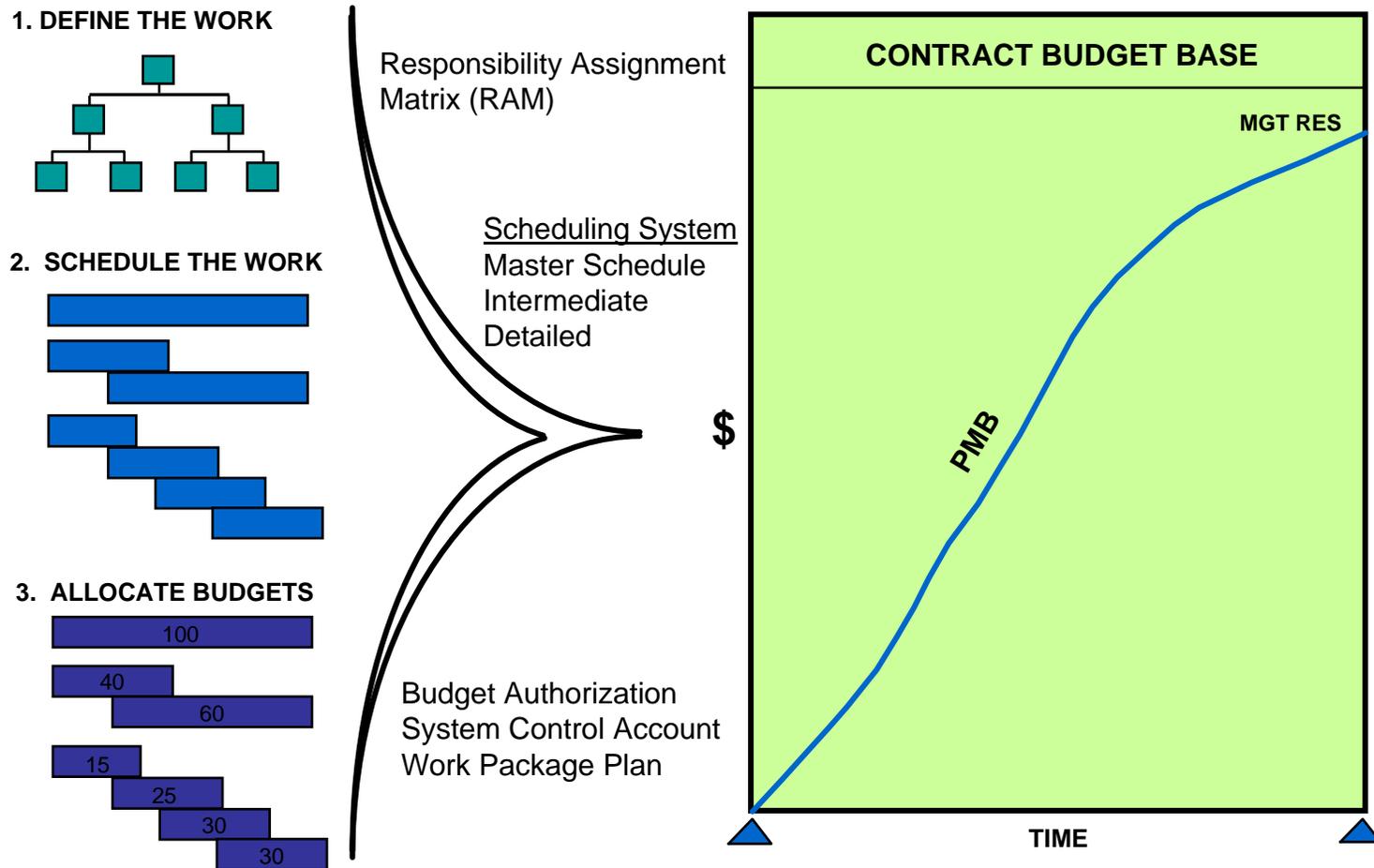
The Performance Measurement Baseline (PMB) – Is ALL the work planned?

What is the PMB?

- A time-phased budget plan against which contract performance is measured
- Developed by the contractor and jointly reviewed with the customer within six months of contract award
- Based on the anticipated flow of work and outcomes
- Incorporates dynamic, authorized project changes

PMB Development

Establishing the PMB is a 3-step process

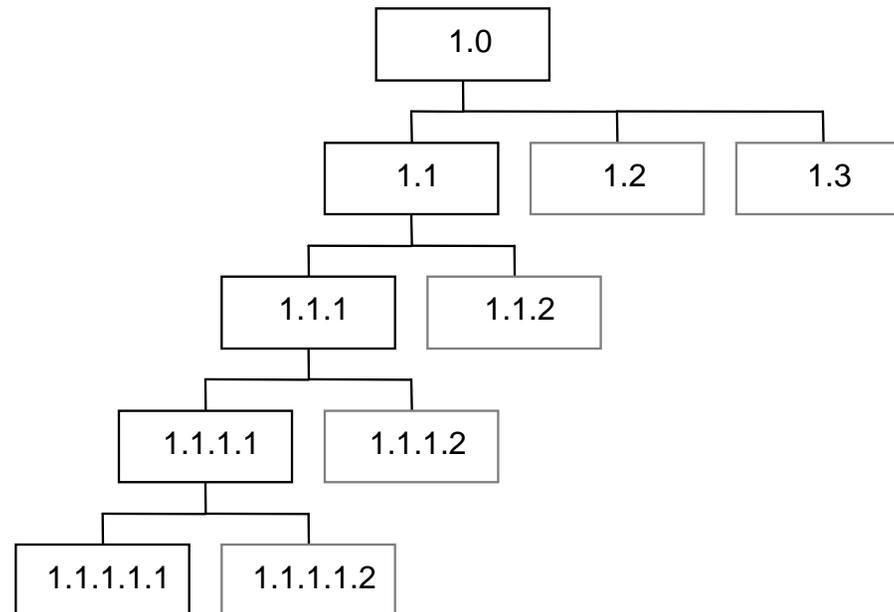


PMB – Time-phased budgeted task plan against which contract performance is measured.

Work Breakdown Structure (WBS)

The WBS is a product-oriented organization of the program/project work used as a **COMMON** structure for managing:

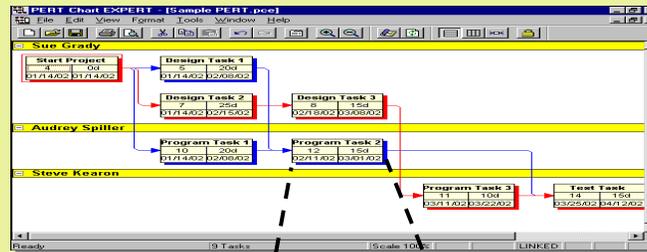
- **Project Technical Definition**
- **Program Control**
- **Pricing & Estimating**
- **Schedule Development**
- **Performance Reporting**



Vertical Schedule Integration

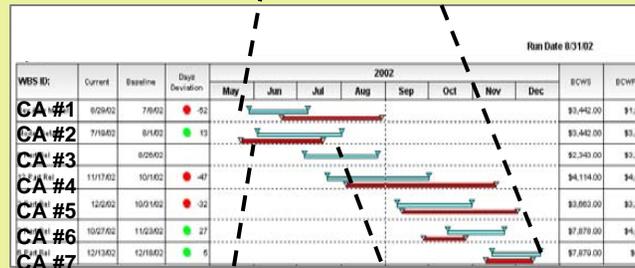
VSI ensures all tasks track from the top down and bottom-up

Project Level



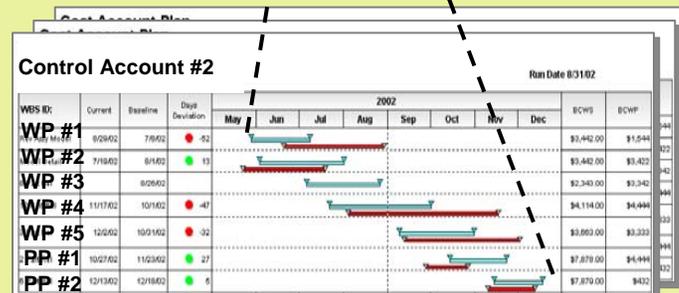
Contract Project Schedule

Intermediate Level



Major Event or Functional Organization Milestone Schedule

Detail Level



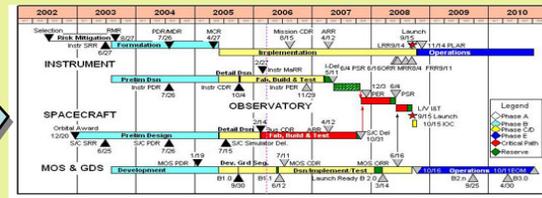
Control Account & Work Package Schedules

Horizontal & Vertical Schedule Integration

The Scheduling System: Consists of an integrated, multi-tiered hierarchy of schedule levels. With a complete **Logic Network Schedule**, the time-phased **PMB will be accurate**, allowing for the identification of the **true critical path(s)**.

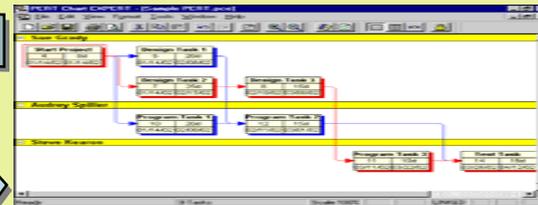
**Master Schedule
(Contract Summary)**

INTEGRATED MASTER SCHEDULE (IMS)



**Intermediate Schedule
(Logic Network Schedule)**

VERTICAL
INTEGRATION



HORIZONTAL
INTEGRATION

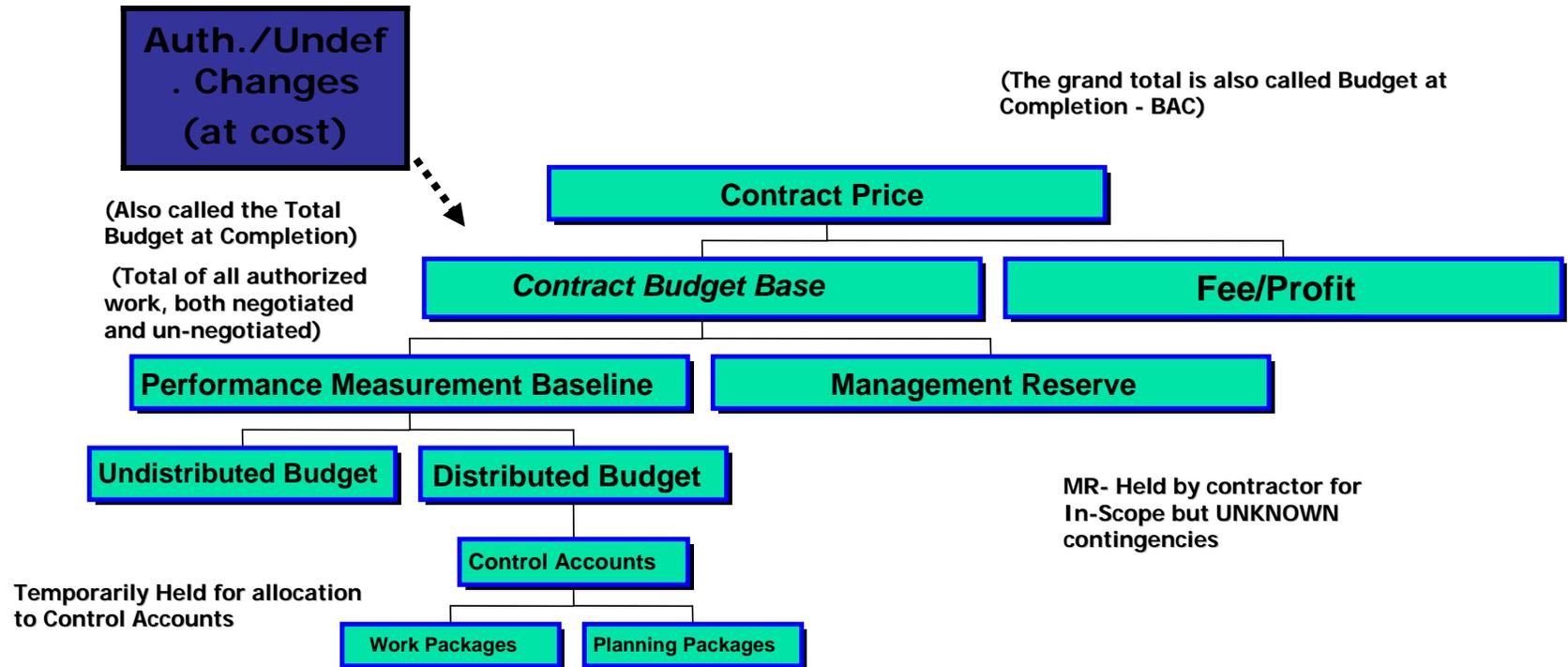
**Detailed Schedules
(Control Accounts)**



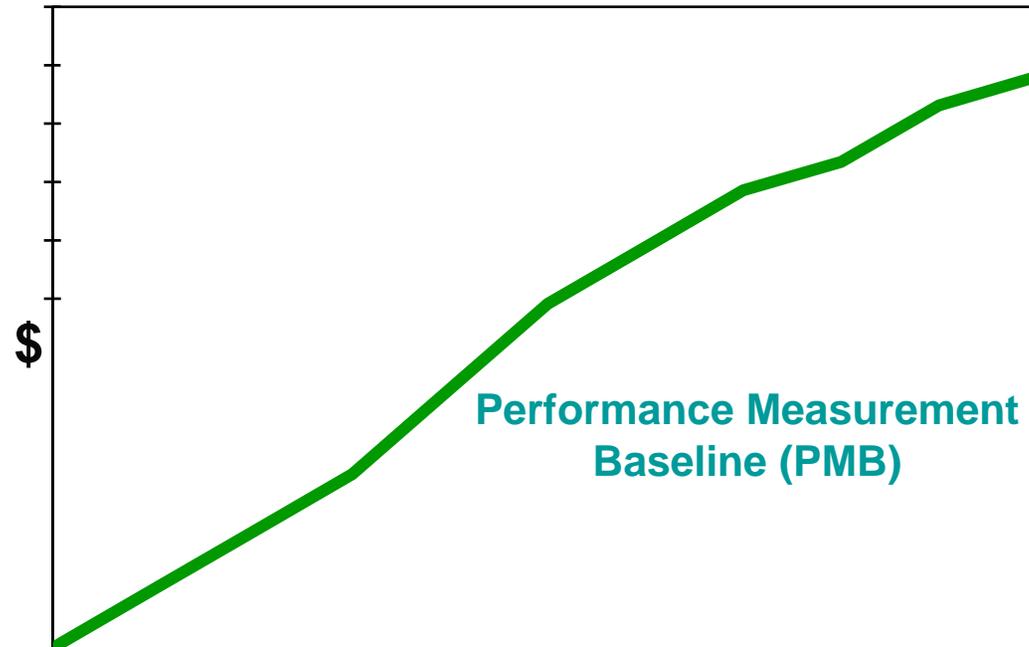
Schedule Considerations

- Are the project logic and sequence established and valid?
- Are the schedule milestones compatible with the project logic?
- Is the critical path analysis available and logical?
- Are durations reasonable compared with other projects history?
- Are resources used to their maximum?
- Are parallel activities reasonable or risky? (i.e. flight hardware being built before qualification is complete)

The Contract / PMB Relationship



Building the PMB



What must be done?

- Technical
- Specifications
- Performance

How it must be done and by whom?

- Scope
- SOW/WBS
- Work Auth.

When it must be done?

- Plans
- Schedule

For how much?

- Budget

PMB Development (Cont.)

- Using the Work Breakdown Schedule (WBS):
 - Develop a logic network schedule for all contractual activities, including technical performance parameters/outcomes
 - Scheduling is a process of changing work scope into defined tasks:
 - WBS Oriented
 - Defined Time Duration (phased over the total life of the program)
 - Logically Connected to All Other Related Tasks
- The master schedule and lower level schedules must provide VERTICAL and HORIZONTAL traceability

PMB Development (Cont.)

- Using the Work Breakdown Schedule (WBS):
 - Determine resources required to complete scheduled activities
 - Labor
 - Direct Labor
 - Civil Service Labor (when applicable)
 - Support Contractors
 - Material
 - Subcontracts
 - Other Direct Costs
 - Indirect Costs
 - Time-phase the resources
 - The cumulative value of these activities produces your PLAN – the PMB, also referred to as the Budgeted Cost for Work Scheduled (BCWS)

EVM Forecasting Concepts

- Estimate At Completion (EAC):
 - Actual direct and indirect costs allocable to the contract, plus the estimate of all costs for authorized work remaining
 - Estimated cost to complete the entire project scope of work
 - Often quite subjective
 - Usually optimistic (or “politically” constrained)
 - There are many ways to calculate an EAC
- Latest Revised Estimate (LRE)
 - Contractor’s estimate to complete the entire project scope of work

EVM Metrics

- **How is Earned Value Calculated?**
 - **When planning work three basic classifications are used:**
 - **Discrete Work – Definable end product**
 - **Level of Effort (LOE) – End product not defined**
 - **Appportioned Effort – Budgeted based on a portion of the total value of the end item (e.g. Quality Assurance)**
 - **Earned Value MUST be taken in the SAME MANNER in which the work was planned**

Discrete Earned Value Measurement Methods

0-100 Method



0%

100%

- One accounting period
- No E.V. at start
- One hundred percent E.V. at completion



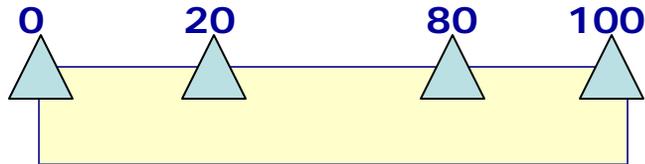
50%

50%

- Two to three accounting periods
- Fifty percent E.V. at start
- Fifty percent E.V. at complete

Discrete Earned Value Measurement Methods

Milestone



- Identifiable milestone
- Milestone weighting should correlate to the resources required to accomplish the task
- Three or more accounting periods

Percent Complete

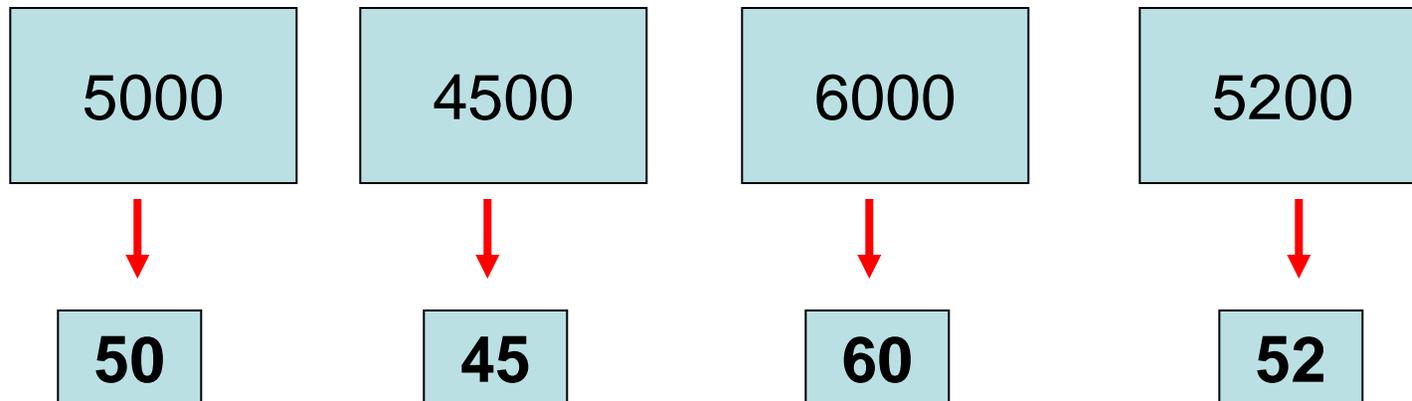


- Least desirable
- Somewhat subjective
- Try to use least subjective parameter
- Limit Percent of EV taken until finished

Earned Value Techniques

Apportioned Work

- Work that is dependent on or related to the performance of other discrete effort in direct proportion
- Not often used in R&D environment



Schedule Performance Index

- SPI is an Monthly and Cumulative Schedule "Efficiency" Indicator
- $SPI = \text{Earned Value} / \text{Plan}$
- Greater than 1.0 is Favorable & Less than 1.0 is Unfavorable
- One of several indicators related to the Performance of the Project
- Did a month's of schedule produce a month of progress?

	Oct	Nov	Dec	Jan	Feb	Mar	Cumulative
Planned Spend (\$)	10	15	10	25	20	20	100
Earned Value (\$)	10	15	10	10	20	17	92
SPI	1.0	1.0	1.0	.40	1.0	.85	.92

- Analysis

- $SPI = EV / \text{Plan} = 92/100 = .92$

You have Accomplished
\$0.92 Worth of Schedule
for Every \$1 Spent

This is
Unfavorable...

Cost Performance Index

- CPI is an Monthly and Cumulative Cost “Efficiency” Indicator
- $CPI = \text{Earned Value} / \text{Actual}$
- Greater than 1.0 is Favorable, Less than 1.0 is Unfavorable
- One of several indicators related to the Performance of the Project
- Did the cost of adding “equity” equal the “equity” added?

	A	B	C	D	E	F	Cumulative
Earned Value (\$)	10	15	10	10	20	*	65
Actual Cost (\$)	9	22	8	30	22	*	71
CPI	0	0	0	-15	0	*	.915

Timenow

- **Analysis**

- $CPI = EV / \text{Actuals} = 65 / 71 = .915$

You have Accomplished
\$0.92 Worth for Every \$1
Spent

This is
Unfavorable...

EVM Forecasting Concepts

Variance At Completion (VAC)

Comparing what the total job is supposed to cost...

BAC

To

What the job is currently estimated to cost...

EAC

Gives

(Estimated) Variance at Completion

VAC

$$\mathbf{VAC = BAC - EAC (OR LRE)}$$

Future Performance Predicators

Estimate At Completion (EAC)

- There are many ways to calculate an EAC
- An Example Formula
 - $EAC = \text{Actuals} + (\text{Work Remaining}/\text{Performance Factor})$
 - $EAC = ACWP + [(BAC - BCWP)/\text{Performance Factor}]$
 - SPI As An Indicator Of EAC Is Better In first 50% (early stages) of a Project
 - There is no substitute for GOOD program information
- Common Performance Factors
 - Cost Performance Index (CPI)
 - Schedule Performance Index (SPI)
 - WEIGHTED (80/20 or some other ratio)



Using EVM Data as a Predictor *

- When a contract is more than 15% complete & more than 10% overrun:
 - *The overrun at completion will be more than the overrun incurred to date*
- The final cost variance (in dollars or as a percentage) will be worse than the cost variance at the 20 percent completion point.
- * Based on OSD database of more than 500 major DoD contracts since 1977



EAC - Rules of Thumb

- Recovery is difficult when:
 - CV is -15% or greater and contract is more than 50% complete
- EAC trends usually do not reverse themselves
- No single EAC methodology is always THE BEST
- *There is no substitute for familiarity with the project !!*



EAC - Rules of Thumb (Cont.)

Evaluating the Estimate at Completion (EAC)

- EACs can be reliably calculated using EVM data when projects are more than 20% complete
 - The cumulative cost performance index (CPI) will not change by more than 0.10 from its value at the 20 percent completion point, and in most cases it only worsens.
- The EAC computed using the cumulative CPI is a reasonable lower bound to the final cost of a contract.

Source: Validated by empirical analysis of completed defense acquisition contracts (Christensen 1993 and 1996; Christensen and Heise 1993; Christensen and Payne 1992). Reaffirmed by recent studies (EAC EVALUATION METHODS: DO THEY STILL WORK? David Christensen, Ph.D. and Carl Templin, Ph.D., DRAFT 13 March 2001). (IS THE CPI-BASED EAC A LOWER BOUND TO THE FINAL COST OF POST A-12 CONTRACTS? David Christensen, Ph.D. and David A. Rees, Ph.D., DRAFT 21 September 2001)

Budget Baseline Log

Date	Description	Contract Target Cost (CTC)	Authorized Unpriced Work (AUW)	CBB	Management Reserve	PMB	Undistributed Budget	Distributed Budget
1/14	ABC Contract	120	-	120	10	110	10	100
1/31	January Summary	120	-	120	10	110	10	100
2/5	Contract Change No. 001	-	45	45	5	40	-	40
2/15	P.O. Letter-Additional Management Reports	-	30	30	-	30	-	30
2/23	P.O. Letter-Motor Redesign	-	30	30	-	30	-	30
2/28	February Summary	120	105	225	15	210	10	200

Questions?